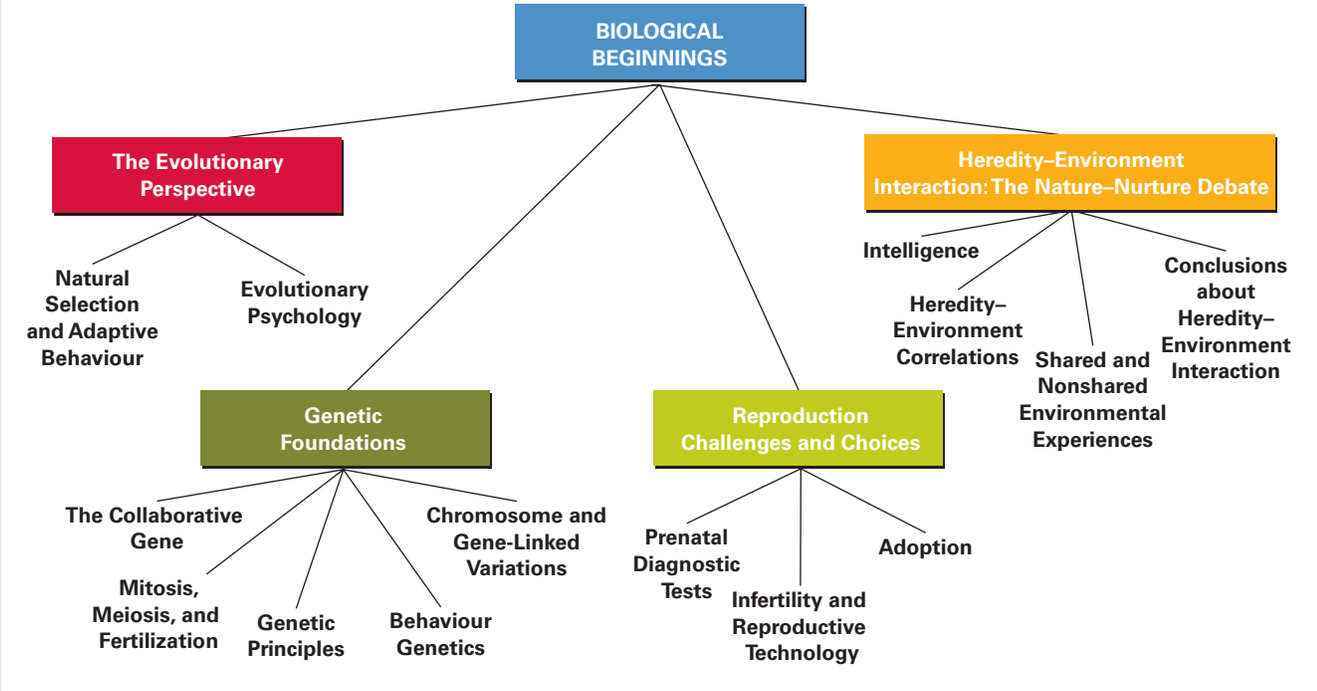
Section 2
Beginnings

CHAPTER 3

Biological Beginnings



There are one hundred and ninety-three living species of monkeys and apes. One hundred and ninety-two of them are covered with hair. The exception is the naked ape, self-named Homo sapiens.

Desmond Morris, Contemporary British Zoologist

IMAGES OF LIFE-SPAN DEVELOPMENT

Four Lives—Four Dilemmas

After three years of marriage, Usha and Henri think they would like to have a baby. Henri's younger brother was autistic and Henri wasn't sure if he carried the gene for this condition. Usha's cousin had the mental age of three months although she was 10 years old. Troubling thoughts about their genetic make-up was one of the reasons they had postponed this commitment. They had heard that some prenatal procedures could diagnose brain conditions in the fetus. They decided they would undergo genetic screening before becoming pregnant to see if they carried the genes involved in autism and brain conditions.

Hua and Li, who immigrated to Canada 18 months ago, just learned that Hua is pregnant. Li was certain that they would have a boy and wanted Hua to undergo amniocentesis right away so they would learn the child's gender. He couldn't wait to call his parents in China to tell them he was going to have a son. Hua did not want to undergo amniocentesis because she did not want to know. She worried that her husband would be so disappointed if the fetus were female that he would not accept a daughter and would want her to have an abortion.

Stephanie and her partner, Ray, learned through maternal serum screening that their unborn child could be born with Down syndrome. Stephanie recalled working as a volunteer lifeguard with physically challenged children and many resources were available, including support groups for parents and families. Since most of the resources are not government subsidized and they feared that one of them might have to give up a successful career in order to provide adequate support, they worried about their financial strength. Ray's parents encouraged Stephanie to abort, but her own mother's words, "Every child brings his or her own special love," echoed in Stephanie's mind.

Moira and her partner Joanne are considering in-vitro fertilization in order to have a child. Moira's parents were thrilled at the prospect of becoming grandparents, but Joanne's parents were horrified at the thought because they would have to acknowledge their daughter's lesbian relationship publicly. They worried about the safety and expenses of the procedure; plus, they were very worried that the child raised by two women would grow up to be a homosexual, too.

Each individual's life will be irrevocably altered no matter what decisions they make. Chapter 3 examines the nature of our biological beginnings and some of the ethical debates surrounding reproductive technologies. After reading the chapter, how would you advise each couple if they sought your opinion?

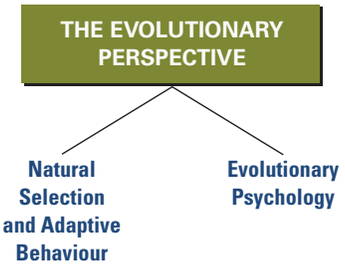
What if parents could choose the genetic character of a person, making her or him attractive, intelligent, and strong? What if Usha and Henri could be sure their child would not have autism or mental retardation, if Hua and Li could determine the gender of their child before conception, if Stephanie and Ray could have in-vitro surgery and treatments to reverse Down syndrome, or if Moira and Joanne could influence their child's sexual orientation? Some suggest this would be morally unthinkable; others see a reduction in health and social care costs and think by this means we could create a perfect world. Would genetically enhanced humans be able to escape cancer, Alzheimer's, or criminal behaviour? Certainly, there are environmental factors which lead to the first two, and the third is really defined by laws, which are created on the basis of the values of those in government. Perhaps we could select those people who we believed had outstanding qualities and clone them. Would the exact physical copy have the same psychological attributes? How much influence would life-history and environment have on individuals with exactly the same genetic make-up?

One way in which psychologists currently study these last two questions is through research on twins. Thomas Bouchard and his colleagues address these questions as part of the Minnesota Study of Twins Reared Apart. They bring identical twins (identical genetically because they come from the same fertilized egg) and fraternal twins (dissimilar genetically because they come from different fertilized eggs) from all over the world to Minneapolis to investigate their lives. The twins are given a number of personality tests and detailed medical histories are obtained, including information about diet and smoking, exercise habits, chest X-rays, heart stress tests, and EEGs (brain-wave tests). The twins are interviewed and asked more than 15,000 questions about their family and childhood environment, personal interests, vocational orientation, values, and aesthetic judgments. They also are given ability and intelligence tests (Bouchard & others, 1990).

Critics of the Minnesota identical twins study point out that some of the separated twins were together several months prior to their adoption, that some of the twins had been reunited prior to their testing (in some cases, a number of years earlier), that adoption agencies often place twins in similar homes, and that even strangers who spend several hours together and start comparing their lives are likely to come up with some coincidental similarities (Adler, 1991). Nevertheless, the Minnesota study of identical twins indicates that scientists recently have shown an increased interest in the genetic basis of human development and that we need further research on genetic and environmental factors (Bouchard, 1995).

The possibility of human cloning stimulates us to think about our genetic heritage and the biological foundations of our existence. Organisms are not like billiard balls, moved by simple, external forces to predictable positions in life. Environmental experiences and biological foundations work together to make us who we are. Our coverage of life's biological beginnings in this chapter focuses on theories and research about evolution, genetic foundations, reproduction challenges and choices, and the interaction of heredity and environment.

THE EVOLUTIONARY PERSPECTIVE



In evolutionary time, humans are relative newcomers to Earth, yet we have established ourselves as the most successful and dominant species. If we consider evolutionary time as a calendar year, humans arrived here in the last moments of December (Sagan, 1977). As our earliest ancestors left the forest to feed on the savannah, and finally to form hunting societies on the open plains, their minds and behaviours changed. How did this evolution come about?

Natural Selection and Adaptive Behaviour

Natural selection is the evolutionary process that favours individuals of a species that are best adapted to survive and reproduce. To understand natural selection, let us return to the middle of the 19th century, when Charles Darwin was travelling around the world, observing many different species of animals in their natural surroundings. Darwin, who published his observations and thoughts in *On the Origin of Species* (1859), observed that most organisms reproduce at rates that would cause enormous increases in the population of most species, and yet populations remain nearly constant. He reasoned that an intense, constant struggle for food, water, and resources must occur among the many young born each generation because many of the young do not survive. Those that do survive pass on their genes to the next generation. Darwin believed that those who do survive to reproduce are probably superior in a number of ways to those who do not. In other words, the survivors are better adapted to their world than are the nonsurvivors (Raven & others, 2002). Over the course of many generations, organisms with the characteristics needed for survival would comprise a larger percentage of the population of a given species. Over many, many generations, this could produce a gradual modification of the whole population. If environmental conditions change, however, other characteristics might become favoured by natural selection, moving the process in a different direction (Freeman & Herron, 2007; McKee, Poirier & McGraw, 2005).

To understand the role of evolution in behaviour, we need to understand the concept of adaptive behaviour. In evolutionary conceptions of psychology, adaptive behaviour is behaviour that promotes an organism's survival in the natural habitat. Adaptive behaviour involves the organism's modification of its behaviour to include its likelihood of survival (Cosmides & others, 2003). All organisms must adapt to particular places, climates, food sources, and ways of life. Natural selection designs adaptation to perform a certain function. An example of adaptation is an eagle's claw, designed by natural selection to facilitate predation. In the human realm, attachment is a system designed by natural selection to ensure an infant's closeness to the caregiver for feeding and

Human Genome Project

Evolution
Evolution and Behaviour

protection from danger. Sickness and aversion to certain foods during pregnancy may be an evolution-based adaptation that enhances the offspring's ability to survive (Schmitt & Pilcher, 20040.

Evolutionary Psychology

Although Darwin introduced the theory of evolution by natural selection in 1859, his ideas about evolution have only recently become popular as a framework for explaining behaviour (Silverman, 2003). **Evolutionary psychology**, *emphasizes the importance of adaptation, reproduction, and "survival of the fittest" in explaining behaviour.* Evolution favours organisms that are best adapted to survive and reproduce in a particular environment. The evolutionary psychology approach focuses on conditions that allow individuals to survive or cause them to fail. In this view, the evolutionary process of natural selection favours behaviours that increase organisms' reproductive success and their ability to pass their genes to the next generation (Bjorklund 2006; Geary, 2006).

evolutionary psychology
A contemporary approach that emphasizes that behaviour is a function of mechanisms, requires input for activation, and is ultimately related to survival and reproduction.

David Buss's (1995, 1999, 2000, 2004) ideas on evolutionary psychology have ushered in a whole new wave of interest in how evolution is involved in explaining human behaviour. He believes that just as evolution shapes our physical features, such as body shape and height, it also pervasively influences how we make decisions, how aggressive we are, our fears, and our mating patterns.

Humans, more than any other animal, adapt to and control most types of environments. Because of longer parental care, humans learn more complex behaviour patterns, which contribute to adaptation. *What are some other adaptive aspects of human behaviour that might be tied to evolution?*

Evolution and Development

Recently, interest has grown in using the concepts of evolutionary psychology to understand human development (Geary, 2006). Here are a few ideas proposed by evolutionary developmental psychologists (Bjorklund & Pellegrini, 2002, pp. 336–340):

- *An extended juvenile period evolved because humans require time to develop a large brain and learn the complexity of human social communities.* Humans take longer to become reproductively mature than any other mammal (see figure 3.1). During this juvenile period they develop a large brain and the experiences required for mastering the complexities of human society.
- *"Many aspects of childhood function as preprations for adulthood and were selected over the course of evolution."* Play is one possible example. Beginning in the preschool years, boys in all cultures engage in more rough-and-tumble play than girls. Perhaps rough-and-tumble play prepares boys for fighting and hunting as adults. In contrast to boys, girls engage in play that involves more imitation of parents, such as caring for dolls, and less physical dominance. This, according to evolutionary psychologists, is an evolved tendency that prepares females for becoming the primary caregivers for their offspring.
- *Some characteristics of childhood were selected because they are adaptive at specific points in development, not because they prepare children for adulthood.* For example, some aspects of play may function, not to prepare us for adulthood, but to help children adapt to their immediate circumstances, perhaps to learn about their current environment.
- *Many evolved psychological mechanisms are domain-specific.* That is, the mechanisms apply only to a specific aspect of a person's makeup (Atkinson & Wheeler, 2004; Rubenstein, 2004). According to evolutionary psychology, information processing is one example. In this view, the mind is not a general-purpose device that can be applied equally to a vast array of problems. Instead, as our ancestors dealt with certain recurring problems, specialized modules evolved that process information related to those problems. This includes a module for physical knowledge, a module for mathematical knowledge, and a module for language. Also in this view, "infants enter the world 'prepared' to process and learn some information more readily than others, and these preparations serve as the foundation for social and cognitive development." For example, much as goslings in Lorenz' experiment (described in Chapter 2) were "prepared" to follow their mother, human infants are biologically prepared to learn the sounds that are part of human language.

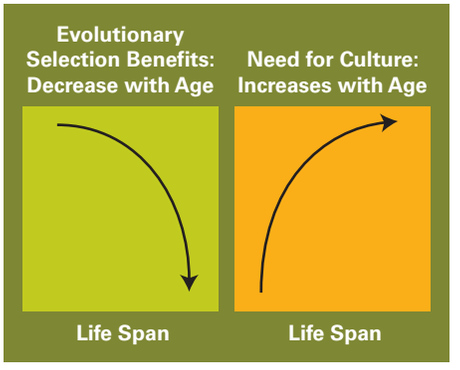


FIGURE 3.1
Baltes's View of Evolution and Culture across the Life Span

- *Evolved mechanisms are not always adaptive in contemporary society.* Some behaviors that were adaptive for our prehistoric ancestors may not serve us well today. For example, the food-scarce environment of our ancestors likely led to humans' propensity to gorge when food is available and to crave high-caloric foods. This trait, as adaptive as it may seem, might be partially responsible for the growing number of obese children in the world.

Evolution and Life-Span Development In evolutionary theory, what matters is that individuals live long enough to reproduce and pass on their genetic characteristics (Johnson, 2006; Mader, 2006, 2007; Promislow, Fedorka, & Burger, 2006). Why, then, do humans live so long after viable reproduction? Perhaps evolution favored longevity because the work and presence of social elders improves the survival rates of babies. For example, the ability of grandparents to care for the young while parents were out hunting and gathering food created an evolutionary advantage.

According to life-span developmentalist Paul Baltes (1996; Baltes, Staudinger, & Lindenberger, 1999), the benefits of evolutionary selection decrease with age. Natural selection has not influenced the prevalence of conditions that mostly affect older adults, but rather does for those that are tied to reproductive fitness earlier in the lifespan. As older adlts weaken biologically, they need culture-based recources (material, social, economic, psychological). For example, for cognitive skills to continue into old age at comparable levels of performance to earlier in adlthood, cognitive support and training are needed (Hoyer, Rybash & Roodin, 2003). And, as we indicated in Chapter 1, Baltes also stresses that a life-span shift in the allocation of resources takes place away from growth and toward maintenance and the regulation of loss.

Evolutionary Psychology
Handbook of Evolutionary Psychology
Evolutionary Psychology Resources

A concrete example of a decrease in evolutionary-selection benefits in older adults involves Alzheimer's disease, a progressive, irreversible brain disorder characterized by gradual deterioration. This disease does not typically appear before age 70. If the disease struck 20-year-olds, perhaps natural selection would have eliminated it eons before the birth of Alois Alzheimer, the German physician who first discovered the anatomical changes in the brain associated with it (Alzheimer's Association, 2007). Possibly, such diseases as Alzheimer's emerge in later life because evolutionary pressures based on reproductive fitness do not select against individuals prone to them.

Evaluating Evolutionary Psychology Albert Bandura (1998), whose social cognitive theory was described in Chapter 2, acknowledges the important influence of evolution on human adaptation and change. However, he rejects what he calls "one-sided evolutionism," which sees social behaviour as the product of evolved biology. An alternative is the *bi-directional view*, in which environment and biological conditions influence each other. Evolutionary pressures created changes in biological structures for the use of tools, which enabled organisms to manipulate, alter, and construct new environmental conditions. Increasingly complex environmental innovations in turn produced new selection pressures for the evolution of specialized biological systems for consciousness, thought, and language.

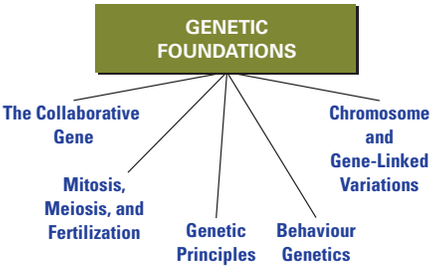
Human evolution gave us bodily structures and biological potentialities, not behavioural dictates. Having evolved, advanced biological capacities can be used to produce diverse cultures—aggressive, pacific, egalitarian, or autocratic. Steven Jay Gould (1981) concluded that in most domains of human functioning, biology allows a broad range of cultural possibilities. Theodore Dobzhansky (1977) reminds us that the human species has been selected for the ability to learn and plasticity—for the capacity to adapt to diverse contexts, not for biologically-fixed behaviour. Bandura (1998) points out that the pace of social change demonstrates that biology does permit a wide range of possibilities.

To this point, we have studied a number of ideas about the evolutionary perspective. A review of these ideas is presented in summary table 3.1.

Summary Table 3.1 The Evolutionary Perspective

Concept	Characteristics/Description
Natural Selection and Adaptive Behaviour	• Natural selection is the process that favours the individuals of a species that are best adapted to survive and reproduce. • The process of natural selection was originally proposed by Charles Darwin.
	• In evolutionary theory, adaptive behaviour is behaviour that promotes the organism's survival in a natural habitat. • Biological evolution shaped human beings into a culture-making species.
	• The view that adaptation, reproduction, and "survival of the fittest" are important in explaining behaviour.
Evolutionary Psychology	• According to Baltes, the benefits of evolutionary selection decrease with age mainly because of a decline in reproductive fitness. • While evolutionary selection benefits decrease with age, cultural needs increase.
Evaluating Evolutionary Psychology	• Social cognitive theorist Albert Bandura acknowledges evolution's important role in human adaptation and change, but argues for a bi-directional view that enables organisms to alter and construct new environmental conditions. • Biology allows for a broad range of cultural possibilities.

GENETIC FOUNDATIONS



Every species must have a mechanism for transmitting characteristics from one generation to the next. This mechanism is explained by the principles of genetics. Each of us carries a genetic code that we inherited from our parents. This code is located within every cell in our bodies. Our genetic codes are alike in one important way—they all contain the human genetic code. Because of the human genetic code, a fertilized human egg cannot grow into an egret, eagle, or elephant.

The Collaborative Gene

Each of us began life as a single cell weighing about one-fifty-millionth of a gram! This tiny piece of matter housed our entire genetic code—information about who we would become. These instructions orchestrated growth from that single cell to a person made of trillions of cells, each containing a perfect replica of the original genetic code.

The nucleus of each human cell contains **chromosomes**, *which are threadlike structures that are made up of deoxyribonucleic acid, or DNA.* **DNA** *is a complex molecule that has a double helix shape, (like a spiral staircase), and contains genetic information.* **Genes**, *the units of hereditary information, are short segments composed of DNA. Genes act as a blueprint for cells to reproduce themselves and manufacture the proteins that maintain life.* Proteins are the building blocks of cells as well as the relators that direct the body's processes (Hartwell, 2008, Johnson, 2006). Chromosomes, DNA, and genes can be mysterious. Figure 3.2 will help you turn mystery to understanding.

chromosomes
Threadlike structures that are made up of deoxyribonucleic acid, or DNA.

DNA (deoxyribonucleic acid)
A molecule in the shape of a double helix which contains genetic information.

genes
Units of hereditary information composed of DNA. Genes act as a blueprint for cells to reproduce themselves and manufacture the proteins that maintain life.

Mitosis, Meiosis, and Fertilization

Genes are not only collaborative; they are enduring. How do the genes manage to get passed from generation to generation and end up in all of the trillion cells in the body? Three processes explain the heart of the story: mitosis, meiosis, and fertilization.

Mitosis is the term applied to the division of autosomal (body) cells. It requires that the chromosomes be duplicated before the cell divides so that each new cell will have the correct number of chromosomes. Each of our body cells has 23 pairs or 46 individual

mitosis
The process of cell division during which cellular material is duplicated and two daughter cells are formed.

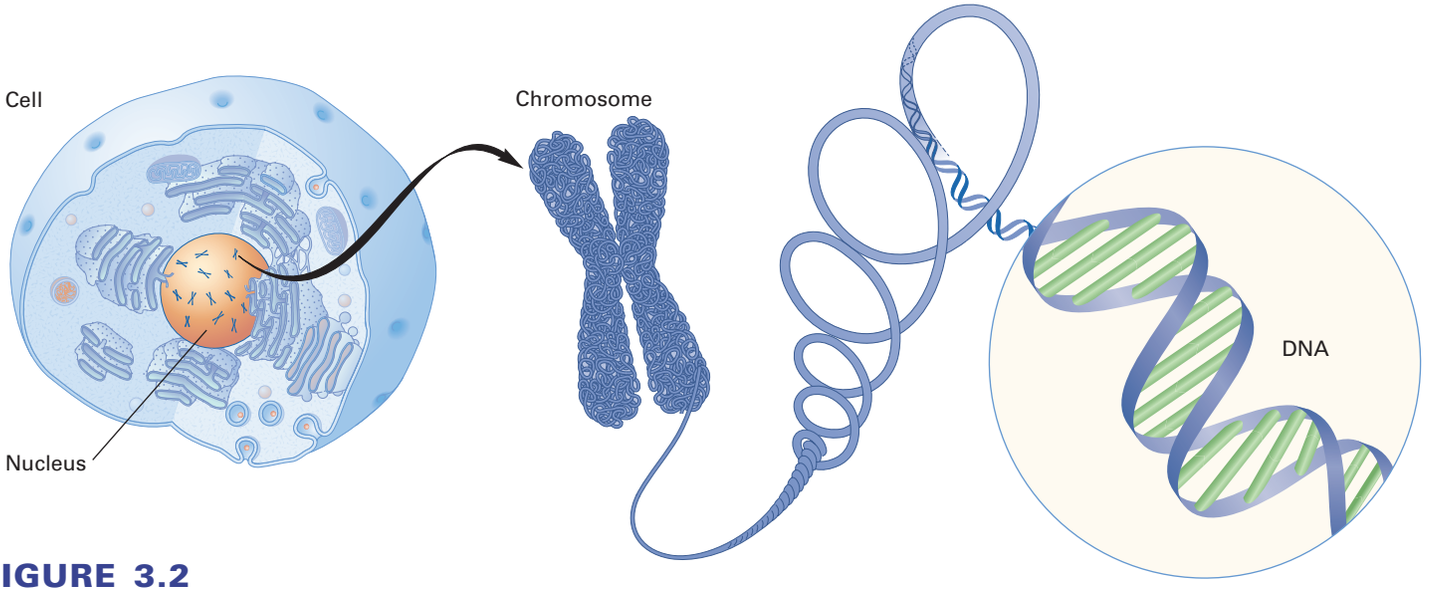


FIGURE 3.2
Cells, Chromosomes, Genes, and DNA

(*Left*) The body contains trillions of cells, which are the basic structural units of life. Each cell contains a central structure, the nucleus. *(Middle)* Chromosomes and genes are located in the nucleus of the cell. Chromosomes are made up of threadlike structures composed of DNA molecules. *(Right)* A gene, a segment of DNA that contains the hereditary code. The structure of DNA is a spiralled double chain.

Farm worker Marc Noel attends to Canada's first cloned calf, Starbuck II.

meiosis
The process of cellular division that divides sex cells and produces four daughter cells, each with 23 single chromosomes.

fertilization
The process that, in humans, begins when a female gamete (ovum) fuses with by a male gamete (sperm) to create a zygote.

zygote
A single cell formed when an ovum is fertilized by a sperm.

chromosomes. This number includes 22 autosomal (body) pairs and one pair of sex chromosomes. During mitosis, the cell's nucleus, including the chromosomes, duplicates itself and the cell divides. Two new cells are formed, containing the same DNA as the original cell, and arranged in the same 23 pairs of chromosomes.

Meiosis, a different type of cell division, is the process during which a cell of the testes (in men) or ovaries (in women) duplicates its chromosomes, but then divides twice, forming four new cells. Each of the new cells (gamates) has half the genetic material of the parent cell. When meiosis is complete, each egg or sperm has 23 unpaired chromosomes, called gamates.

Fertilization is the process by which an egg and a sperm fuse to create a single cell, called a **zygote** (See figure 3.3). In the zygote, the 23 unpaired chromosomes from the egg and the other 23 unpaired chromosomes from the sperm combine to form one set of 23 paired chromosomes (See figure 3.5). In this manner, each parent contributes half of the offspring's genetic material.

Figure 3.5 shows 23 paired chromosomes of a male and female. The members of each pair of chromosomes are both similar and different: Each chromosome in the pair contains varying forms of the same genes, at the same location on the chromosome. A gene for hair colour, for example, is located in the same place on both members of the same pairing. However, one of those chromosomes might carry the gene for blond hair and the other for brown hair.

Figure 3.5a and b illustrate the difference between the male and female chromosomes. The difference lies in the 23rd pair. Ordinarily, in females, this pair consists of two X chromosomes; in males, the 23rd pair consists of an X and a Y chromosome.

Sources of Variability Combining the genes of two parents in offspring increases genetic variability in the population, which is valuable for a species because it provides more characteristics for natural selection to operate on (Dowan, 2007; Krogh, 2007; Mader, 2006; Lewis, 2007). In fact, the human genetic process creates several important sources of variability.

First, the chromosomes in the zygote are not exact copies of those in the mother's ovaries and the father's testes. During the formation of the sperm and egg in meiosis, the members of each pair of chromosomes are separated, but which chromosome in the pair

goes to the gamete is a matter of chance. In addition, before the pairs separate, pieces of the two chromosomes in each pair are exchanged, creating a new combination of genes on each chromosome. Thus, when chromosomes from the mother's egg and the father's sperm are brought together in the zygote, the result is a truly unique combination of genes (Belk & Borden, 2007; Starr, 2006).

If each zygote is unique, how do identical twins exist? *Identical twins* (also called monozygotic twins) develop from a single zygote that splits into two genetically identical replicas, each of which becomes a person. *Fraternal twins* (called dizygotic twins) develop from separate eggs and separate sperm, making them genetically no more similar than ordinary siblings.

A second source of variability comes from DNA. Chance, a mistake by cellular machinery, or damage from an environmental agent such as radiation may produce a *mutated gene*, which is a permanently altered segment of DNA (Cummings, 2006).

No one possesses all the characteristics that our genetic structure makes possible. A **genotype** *is the person's genetic heritage, the actual genetic material.* However, not all of this genetic material is apparent in our observed and measurable characteristics. A **phenotype** *is the way an individual's genotype is expressed in observed and measurable characteristics.* Phenotypes include physical traits (such as height, weight, eye colour, and skin pigmentation) and psychological characteristics (such as intelligence, creativity, personality, and social tendencies).

Even when their genes are identical, however, people vary. The difference between genotypes and phenotypes helps us to understand this source of variability. All of a person's genetic material makes up his or her genotype. However, not all of the genetic material is apparent in our observed and measurable characteristics. A phenotype consists of observable characteristics.

For each genotype, a range of phenotypes can be expressed. Imagine that we could identify all of the genes that would make a person introverted or extroverted. Would measured introversion-extroversion be predictable from knowledge of the specific genes? The answer is no because even if our genetic model were adequate, introversion/extroversion is a characteristic shaped by experience throughout life. For example, parents may push an introverted child into social situations and encourage the child to become more gregarious.

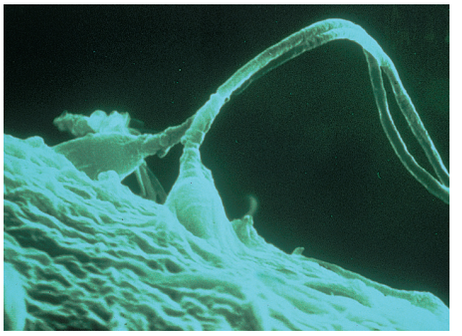


FIGURE 3.3
Union of Sperm and Egg

genotype
A person's genetic heritage; the actual genetic material.

phenotype
The way an individual's genotype is expressed in observed and measurable characteristics.

Genetic Principles

Genetic determination is a complex affair, and much is unknown about the way genes work (Dowan, 2007; Klug, Cummings, & Spencer, 2006; Lewis 2005, 2007). A number of known genetic principles such as dominant-recessive genes, sex-linked genes, polygenically inherited characteristics, reaction range, and canalization are outlined here.

Dominant-Recessive Genes Principle A recessive gene exerts its influence only if both genes of a pair are recessive. If you inherit a recessive gene for a trait from both your parents, you will show the trait. If you inherit a recessive gene from only

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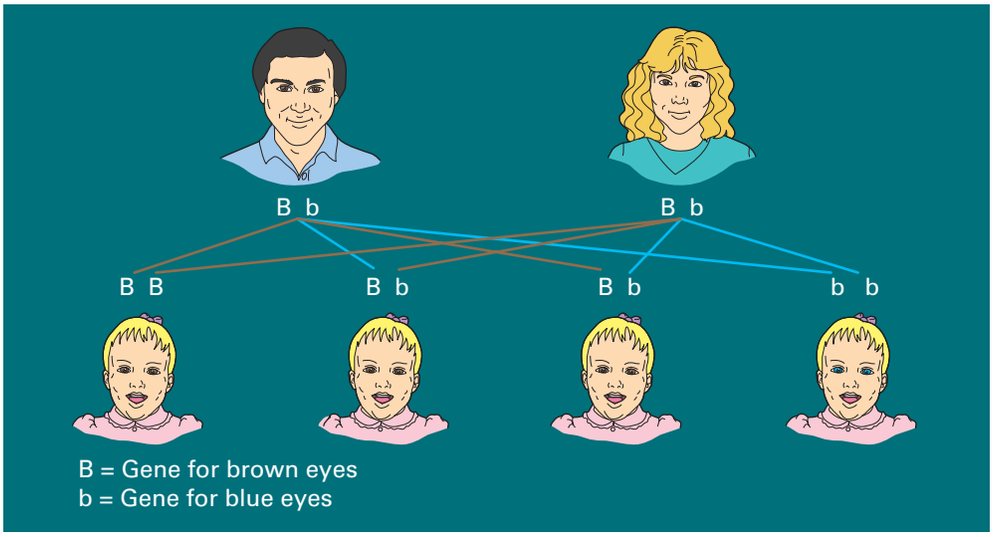
Critical Thinking

According to Genome Canada, (2007) new technologies are all highly contentious and raise a host of complex ethical issues. What are some of the arguments for and against developments such as cloning, genetic screening, and genetically modified foods? Should our genetic information be stored, and if so, who should have access? Should we patent our genes? Or, should we weed out undesirable genetic traits? If so, who decides which traits are desirable and which are not?

FIGURE 3.4
How Brown-Eyed Parents Can Have a Blue-Eyed Child

Although both parents have brown eyes, each parent can have a recessive gene for blue eyes. In this example, both parents have brown eyes, but each parent carries the recessive gene for blue eyes. Therefore, the odds of their child having blue eyes is one in four—the probability the child will receive a recessive gene (b) from each parent.



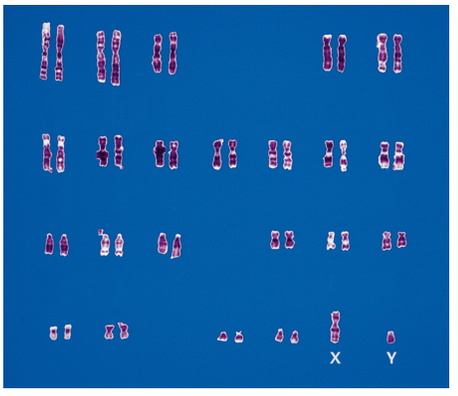
one parent, you may never know you carry the gene. Brown eyes, farsightedness, and dimples rule over blue eyes, nearsightedness, and freckles in the world of dominant-recessive genes. Can two brown-eyed parents have a blue-eyed child? Yes, they can. Suppose that in each parent the gene pair that governs eye colour includes a dominant gene for brown eyes and a recessive gene for blue eyes. Since dominant genes override recessive genes, the parents have brown eyes, but both are carriers of blueness and pass on their recessive genes for blue eyes. With no dominant gene to override them, the recessive genes can make the child's eyes blue. Figure 3.4 illustrates the dominant-recessive genes principle.

Sex-linked Genes For thousands of years, people wondered what determined whether we become male or female. Aristotle believed that the father's arousal during intercourse determines the offspring's sex. The more excited the father was, the more likely it would be a son, he reasoned. Of course, he was wrong, but it was not until the 1920s that researchers confirmed the existence of human sex chromosomes, two of the 46 chromosomes human beings normally carry. Ordinarily, females have two X chromosomes, and males have an X and a Y. (Figure 3.5 shows the chromosomal makeup of a male and a female.)

Most mutated genes are recessive. When a mutated gene is carried on the X chromosome, the result is called *X-linked inheritance* (Turner, 2006). It may have very dif-

FIGURE 3.5
The Genetic Difference between Males and Females

Set *(a)* shows the chromosome structure of a male, and set *(b)* shows the chromosome structure of a female. The last pair of 23 pairs of chromosomes is in the bottom right box of each set. Note that the Y chromosome of the male is smaller than the X chromosome of the female. To obtain this kind of chromosomal picture, a cell is removed from a person's body, usually from the inside of the mouth. The chromosomes are stained by chemical treatment, magnified, and then photographed.



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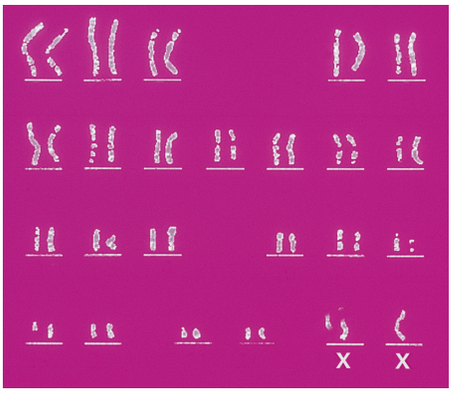


b

ferent implications for males than females. Remember that males have only one X chromosome. Thus, if there is an altered, disease-creating gene on the X chromosome, males have no "backup" copy to counter the harmful gene and therefore may carry an X-linked disease. However, females have a second X chromosome, which is likely to be unchanged. As a result, they are not likely to have the X-linked disease. Thus, most individuals who have X-linked diseases are males. Females who have one changed copy of the X gene are known as "carriers," and they usually do not show any signs of the X-linked disease. Thus, they may not realize they are carriers until they have male children. Hemophilia and fragile X syndrome are examples of X-linked inheritance (Gonzalez-del Angel & others, 2000).

Genetic Imprinting Genetic imprinting occurs when genes have differing effects depending on whether they are inherited from the mother or the father (Abu-Amero & others, 2006; Federman, 2006). A chemical process "silences" one member of the gene pair. For example, as a result of imprinting, only the maternally derived copy of a gene might be active, while the paternally derived copy of the same gene is silenced—or vice versa. Only a small percentage of human genes appear to undergo imprinting, but it is a normal and important aspect of development. When imprinting goes awry, development is affected. Bechwith-Wiedemann syndrome, a growth variation, and Wilms tumor, a type of cancer are the results of errors in the imprinting process.

Polygenic inheritance is the genetic principle that many genes can interact to produce a particular characteristic. Few psychological characteristics are the result of single pairs (Lewis, 2007; Starr, 2006). Most are determined by the interaction of many different genes. And the number of possible combinations is staggering. Traits produced by this mixing of genes are said to be polygenically determined.

Reaction Range To understand how introverted a child is, think about a series of genetic codes that predispose the child to develop in a particular way, and imagine environments that are responsive or unresponsive to this development. For instance, the genotype of some persons may predispose them to be introverted in an environment that promotes a turning inward of personality, yet, in an environment that encourages social interaction and outgoingness, these same individuals may become more extroverted. However, it would be unlikely for the individual with this introverted genotype to become a strong extrovert. The **reaction range** *is the range of possible phenotypes for each genotype, suggesting the importance of an environment's restrictiveness or richness* (see figure 3.6).

Canalization Although some traits have a wide reaction range, others are somewhat immune to extensive changes in the environment. These characteristics seem to stay on a particular developmental course, regardless of the environmental assaults on them (Waddington, 1957). **Canalization** *is the term chosen to describe the narrow path, or developmental course, that certain characteristics take. Apparently, preservative forces help protect, or buffer, a person from environmental extremes.* For example, Jerome Kagan (1984) points to his research on Guatemalan infants who had experienced extreme malnutrition as infants, and yet showed normal social and cognitive development later in childhood.

Behaviour Genetics

Comparing twins reared apart is one of a number of methods used to examine heredity's influence on behaviour. **Behaviour genetics** *is the study of the degree and nature of behaviour's hereditary basis.* Behaviour geneticists assume that behaviours are jointly determined by the interaction of heredity and environment (Goldsmith, 1994; Rowe, 2001; Wahlsten, 2000).

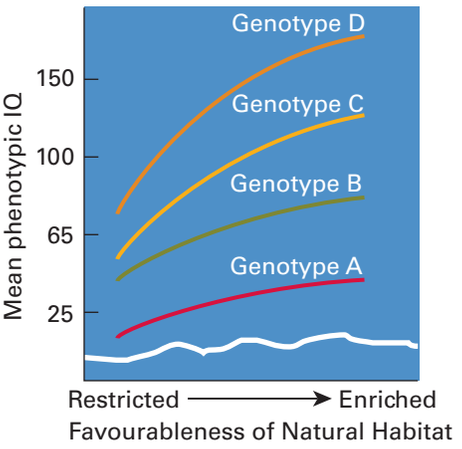


FIGURE 3.6
Responsiveness of Genotypes to Environmental Influences

Although each genotype responds favourably to improved environments, some are more responsive than others to environmental deprivation and enrichment.

Landmarks in the History of Genetics
Heredity Resources
Genetic Journals and News

reaction range
The range of possible phenotypes for each genotype, suggesting the importance of an environment's restrictiveness or richness.

canalization
The process by which characteristics take a narrow path or developmental course. Apparently, preservative forces help protect a person from environmental extremes.

behaviour genetics
The study of the degree and nature of behaviour's basis in heredity.

twin study
A study in which the behavioural similarity of identical twins is compared with the behavioural similarity of fraternal twins.

To study the influence of heredity on behaviour, behaviour geneticists often use either twins or adoption situations. In the most common **twin study**, *the behavioural similarity of identical twins is compared with the behavioural similarity of fraternal twins.* Although fraternal twins share the same womb, they are no more alike genetically than are non-twin brothers and sisters, and they may be of different sexes. By comparing groups of identical and fraternal twins, behaviour geneticists capitalize on the basic knowledge that identical twins are more similar genetically than are fraternal twins (Mitchell, 1999; Plomin & DeFries, 1998; Scarr, 1996). In one twin study, 7,000 pairs of Finnish identical and fraternal twins were compared on the personality traits of extroversion and neuroticism (psychological instability) (Rose & others, 1998). On both these personality traits, the identical twins were much more similar than the fraternal twins, suggesting the role of heredity in both traits. However, several issues crop up as a result of twin studies. Adults might stress the similarities of identical twins more than those of fraternal twins, and identical twins might perceive themselves as a "set" and play together more than fraternal twins. If so, observed similarities in identical twins could be environmentally influenced.

adoption study
A study in which investigators seek to discover whether, in behaviour and psychological characteristics, adopted children are more like their adoptive parents, who provided a home environment, or more like their biological parents, who contributed their heredity. Another form of the adoption study compares adoptive and biological siblings.

In an **adoption study**, *investigators seek to discover whether, in behaviour and psychological characteristics, adopted children are more like their adoptive parents, who provided a home environment, or more like their biological parents, who contributed their heredity. Another form of the adoption study compares adoptive and biological siblings.* In one investigation, the educational levels attained by the biological parents were better predictors of the adopted children's IQ scores than were the IQs of the children's adopted parents (Scarr & Weinberg, 1983). The implication is that heredity influences children's IQ scores.

Chromosome and Gene-Linked Variations

Let us examine some variations that can occur in chromosomes and genes. As you will see, some of these variations involve chromosomes, others harmful genes.

Chromosome Variations

When gametes are formed, the 46 chromosomes do not always divide evenly. In this case, the resulting sperm and ovum do not have their normal 23 chromosomes. The most notable instances when this occurs involve Down syndrome and variations of the sex chromosomes (see figure 3.7).

Other diseases that result from genetic variations include cystic fibrosis, diabetes, hemophilia, Huntington disease, spina bifida, and Tay-Sachs disease. Figure 3.8 provides further information about these diseases. Someday, scientists may identify why these and other genetic variations occur and discover how to cure them. The Human Genome Project has already linked specific DNA variations with increased risk of a number of diseases and conditions, including Huntington disease (in which the central nervous system deteriorates), some forms of cancer, asthma, diabetes, hypertension, and Alzheimer's disease.

Paul (centre) was best man at his sister's wedding. He is seen here with wedding guests and friends.

Every individual carries DNA variations that might predispose the person to serious physical disease or mental disorder. But not all individuals who carry a genetic disorder display the disorder. Other genes or developmental events sometimes compensate for genetic variations (Gottlieb, 2004; Gottlieb, Wahlsten, & Lickliter, 2006).

Thus, genes are not destiny, but genes that are missing, nonfunctional, or mutated can be associated with disorders. Identifying such genetic flaws could enable doctors to predict an individual's risks, recommend healthy practices, and prescribe the safest and most effective drugs. A decade or two from now, parents of a newborn baby may be able to leave the hospital with a full genome analysis of their offspring that reveals disease risks.

Name	Description	Treatment	Incidence
Down syndrome	Extra or altered 21st chromosome causes mild to severe retardation and physical variations.	Surgery, early intervention, infant stimulation, and special learning programs	1 in 1,900 births at maternal age 20 1 in 300 births at maternal age 35 1 in 30 births at maternal age 45
Klinefelter syndrome	An extra X chromosome causes physical variations.	Hormone therapy can be effective	1 in 800 males
Fragile X syndrome	A variation in the X chromosome can cause mental retardation, intellectual disabilities, or short attention span.	Special education, speech and language therapy	1 in 1,500 males 1 in 2,500 females
Turner syndrome	A missing X chromosome in females can cause intellectual disabilities and sexual underdevelopment.	Hormone therapy in childhood and puberty	1 in 3,000 female births
XYY syndrome	An extra Y chromosome can cause above-average height.	No special treatment required	1 in 1,000 male births

FIGURE 3.7
Some Chromosome Variations

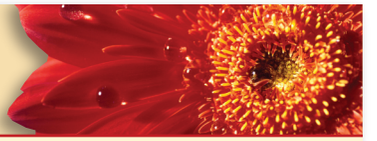
However, this knowledge might bring important costs as well as benefits. Who would have access to a person's genetic profile? An individual's ability to land and hold jobs or obtain insurance might be threatened if it is known that a person is considered at risk for some disease. For example, should an airline pilot or a neurosurgeon who is predisposed to develop a disorder that makes one's hands shake be required to leave that job early? Might this affect their ability to attain the education that would allow them to enter those professions in the first place?

Genetic counselors, usually physicians or biologists who are well versed in the field of medical genetics, understand the kinds of situations just described, the odds of encountering them, and helpful strategies for offsetting some of their effects (Berkowitz, Roberts, & Minkoff, 2005; Finn & Smoller, 2006; Mayeux, 2005; Watson & others, 2005).

Gene-Linked Variations Not only can variations be produced by an uneven number of chromosomes, they also can result from harmful genes (Croyle, 2000). Apart from the single pair of sex chromosomes, the 22 other pairs of chromosomes are referred to as autosomes and account for most of the genetic disorders. The inheritance of the disorders follow one of two paths: either autosomal-dominant or autosomal-recessive. In the autosomal-dominant pattern, one parent will usually be affected with the disorder. If only one parent has the dominant gene, then half the children will exhibit the disorder. If both parents have the gene, then all the children will have the disorder. Examples of disorders generated by the autosomal-dominant gene include: achondroplasia, a bone growth disorder; hereditary colon cancer; and neurofibromatosis I, which causes light brown birthmarks and soft skin lumps over peripheral nerves. In the autosomal-recessive pattern, if both parents are carriers, but not affected by the disorder, each offspring will have a one-in-four chance of being affected. If both parents are affected, then all their children will be as well. If one is affected and the other not at all (not a carrier), then their children will be unaffected but carriers. If one parent is affected and the other is a carrier, then half their offspring will be affected.

SPOTLIGHT ON SOCIAL POLICY

The Human Genome Project: An Update



Each gene has its own location, its own designated place on a particular chromosome. Today, there is a great deal of enthusiasm about efforts to discover the specific locations of genes that are linked to certain functions (Enger, 2007; Lewin, 2006; Lewis, 2007; Nester & others, 2007; Plomin, 2004). The Human Genome Project was initiated in 1990 as an international effort to locate genes in the human genome and determine their sequencing (Health Canada, 2005). An important step in this direction was accomplished when the Human Genome Project and the Celera Corporation completed a preliminary map of the human *genome*—the complete set of developmental instructions for creating proteins that initiate the making of a member of the human species (U.S. Department of Energy, 2001).

One of the big surprises of the Human Genome Project was a report indicating that humans have only about 30,000 genes (U.S. Department of Energy, 2001). More recently, this number is estimated to be 20,000 to 25,000 (International Human Genome Sequencing Consortium, 2004). This contrasts sharply with the belief once held by many scientists that the human genome had 100,000 or more genes, a belief influenced by the erroneous premise that each protein was programmed by a separate gene. In fact, humans appear to have far more proteins than they have genes, therefore, it seems that genes, or some genes, can function to program more than one protein (Commoner, 2002; Moore, 2001).

Rather than being an independent source of developmental information, DNA collaborates with other sources of information to specify our characteristics. The collaboration operates at many points. For example, the cellular machinery mixes, matches, and links small pieces of DNA to reproduce the genes and that machinery is influenced by what is going on around it. Hormones and proteins work in collaboration and are affected by their environment. Events external and internal to the original cell can excite or inhibit genetic expression (Gottlieb, Wahlsten, & Lickliter, 2006).

Some of the medical applications of new genetic knowledge are revolutionary. The use of molecular genetics can help us to discover the specific locations of genes that determine an individual's susceptibility to many diseases, as well as other aspects of health and well being. After this knowledge is attained, what next? One possible strategy may be to find a healthy copy of the missing gene and transplant it into the affected cells. Another is to develop drugs that will alter the genetic makeup of affected cells.

In Canada, Dr. Stephen Schere, senior scientist in the Department of Genetics and Genomic Biology at Sick Kids Hospital in Toronto, is the project leader of the Autism Genome Project, a pioneering initiative which will bring together many of the world's leading genetists. The findings of the Autism Genome Project (2007) will influence dianostic capabilities, treatment, and policy decisions related to autism. The project is funded by Genome Canada, an organization that has received over $700 million from the Canadian governement in an effort to ensure that Canada becomes a world leader in genome research (Genome Canada, 2007).

Dr. Calliopi Havele and Dr. Peter Bretscher of the Microbiology and Immunology Department at the University of Saskatchewan, sound cautionary notes. Dr. Havele said, "Our genetic composition is incredibly complex," to which Dr. Bretscher added, "A genetic tendency towards one trait may easily be offset by something else which counteracts the tendency" (Interview, May 2007). A single gene is rarely the source of a protein's genetic information, much less of an inherited trait (Gottlieb, 2003, 2004; Gottlieb, Wahlsten, & Lickliter, 2006; Moore, 2001). Therefore, rather than individualized and unwavering self-replicators, genes can be considered to be both interdependent and highly influenced by external factors.

Phenylketonuria, sickle-cell anemia, Tay-Sachs disease, and cystic fibrosis are autosomal-recessive disorders. In both patterns, male and female babies are equally affected. More than 7,000 such genetic disorders have been identified, although most of them are rare. Other genetic variations include diabetes, hemophilia, Huntington disease, and spina bifida. Figure 3.8 provides further information about the genetic variations we have discussed.

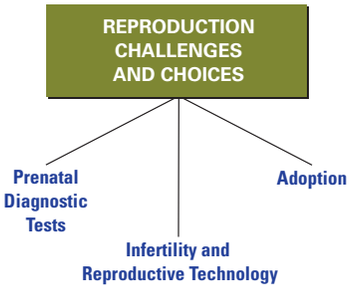
To this point, we have explored a number of ideas about genetic foundations. To review these ideas, see summary table 3.2.

Name	Description	Treatment	Incidence
Cystic fibrosis	Glandular dysfunction that interferes with mucus production; breathing and digestion are hampered, resulting in a shortened life span.	Physical and oxygen therapy, synthetic enzymes, and antibiotics; most individuals live to middle age.	1 in 2,000 births
Diabetes	Body does not produce enough insulin, which causes abnormal metabolism of sugar.	Early onset can be fatal unless treated with insulin.	1 in 2,500 births
Hemophilia	Delayed blood clotting causes internal and external bleeding.	Blood transfusions/ injections can reduce or prevent damage due to internal bleeding.	1 in 10,000 males
Huntington disease	Central nervous system deteriorates, producing problems in muscle coordination and mental deterioration.	Does not usually appear until age 35 or older; death likely 10 to 20 years after symptoms appear.	1 in 20,000 births
Phenylketonuria (PKU)	Metabolic disorder that, left untreated, causes mental retardation.	Special diet can result in average intelligence and normal life span.	1 in 14,000 births
Sickle-cell anemia	Blood disorder that limits the body's oxygen supply; it can cause joint swelling, sickle-cell crises; heart and kidney failure.	Penicillin, medication for pain, antibiotics, and blood transfusions.	1 in 400 North American children of African descent (lower among other groups)
Spina bifida	Neural tube disorder that causes brain and spine variations.	Corrective surgery at birth, orthopedic devices, and physical/medical therapy.	2 in 1,000 births
Tay-Sachs disease	Deceleration of mental and physical development caused by an accumulation of lipids in the nervous system.	Medication and special diet are used, but death is likely by five years of age.	One in 30 North American Jews is a carrier.

FIGURE 3.9
Some Gene-Linked Variations

REPRODUCTION CHALLENGES AND CHOICES

The facts and principles we have discussed regarding mitosis, meiosis, fertilization, and genetics are a small part of the current explosion of knowledge and research about human biology. This research will not only help us understand human development, but will also open up many new choices for prospective parents. Many ethical questions emerge as well.



Prenatal Diagnostic Tests

Scientists have developed a number of tests to determine whether a fetus is developing normally, among them amniocentesis, ultrasonography, chorionic villus sampling, and the maternal serum screening.

Amniocentesis is a prenatal medical procedure in which a sample of amniotic fluid is withdrawn by syringe and tested to discover if the fetus is suffering from any chro-

Summary Table 3.2 Genetic Foundations

Concept	Characteristics/Description
The Collaborative Gene	• The nucleus of each human cell contains 46 chromosomes, which are composed of DNA. • Genes are short segments of DNA and act as a blueprint for cells to reproduce and manufacture proteins that maintain life.
Mitosis, Meiosis, and Fertilization	• Mitosis is the process of cell division.
	• Genes are transmitted from parents to offspring by gametes, or sex cells. • Gametes are formed by the splitting of cells, a process called "meiosis." • Reproduction takes place when a female gamete (ovum) is fertilized by male gamete (sperm) to create a zygote.
Genetic Principles	• Genetic principles include those involving dominant-recessive genes, sex-linked genes, polygenic inheritance, genotype-phenotype influences, reaction range, and canalization.
Behaviour Genetics	• Behaviour genetics is the field concerned with the degree and nature of behaviour's hereditary basis.
	• These include twin studies and adoption studies.
The Human Genome Project	• The Human Genome Project has made stunning progress in mapping the human genome. • Current research is aimed at finding ways to diagnose and treat diseases, as well as to shape health care policies.
Chromosome and Gene-Linked Variations	• These occur when chromosomes do not divide evenly. • Sex-linked chromosomal abnormalities include Klinefelter syndrome, fragile X syndrome, Turner syndrome, and XYY syndrome.
	• These involve harmful genes. • Gene-linked disorders include phenylketonuria (PKU) and sickle-cell anemia.

Amniocentesis
Obstetric Ultrasonography
Chorionic Villi Sampling
Genetic Counselling

mosomal or metabolic disorders (Ransay & others, 2004). Amniocentesis is performed between the 15th and 18th weeks of pregnancy. The later amniocentesis is performed, the better is its diagnostic potential (Pinette & others, 2004). It may take two weeks for enough cells to grow and amniocentesis test results to be obtained.

Ultrasonography is a prenatal medical procedure in which high-frequency sound waves are directed into the pregnant woman's uterus. The echo from the sounds is transformed into a visual representation of the fetus's inner structures. This technique has been able to detect such disorders as microencephaly, a form of mental retardation involving an unusually small brain. Ultrasonography is often used in conjunction with amniocentesis to determine the precise location of the fetus and the number of fetuses in the mother's uterus (see figure 3.9). It can also give clues to the baby's sex (Letterie, 2005; McHugh, Kiely, & Spitz, 2006).

Chorionic villi sampling is a prenatal medical procedure in which a small sample of the placenta is removed at some point between the 10th and 12th weeks of pregnancy to detect genetic variations (Health Canada 2002). Diagnosis takes approximately 10 days. Chorionic villi sampling has a slightly higher risk of miscarriage than amniocentesis and is linked to a slight risk of limb deformities. These techniques provide valuable information about the presence of disabilities, but they also raise issues pertaining to whether an abortion should be obtained if disabilities are present. The International Clearinghouse for Birth Defects Monitoring Systems (2001) surveyed a number of countries and reported that due to prenatal tests diagnosing Down syndrome, 53.2 percent of pregnancies were terminated. The lowest percentage of aborted pregnancies due to the possible presence of Down syndrome was 26.7 in Alberta, Canada, while the highest (84 percent) was found in Paris, France. Figure 3.10 shows how the procedures of amniocentesis and chorionic villi sampling are carried out.

The maternal serum screening (alpha-fetoprotein—AFP) is a prenatal diagnostic technique that is used to identify pregnancies that have an elevated risk for spina bifida, Down syndrome, and other conditions (Echevarria & Avellon, 2006; Nicolaides, 2005).

FIGURE 3.9
Ultrasonography

A six-month-old infant poses with the ultrasonography record taken four months into the baby's prenatal development. *What is ultrasonography?*

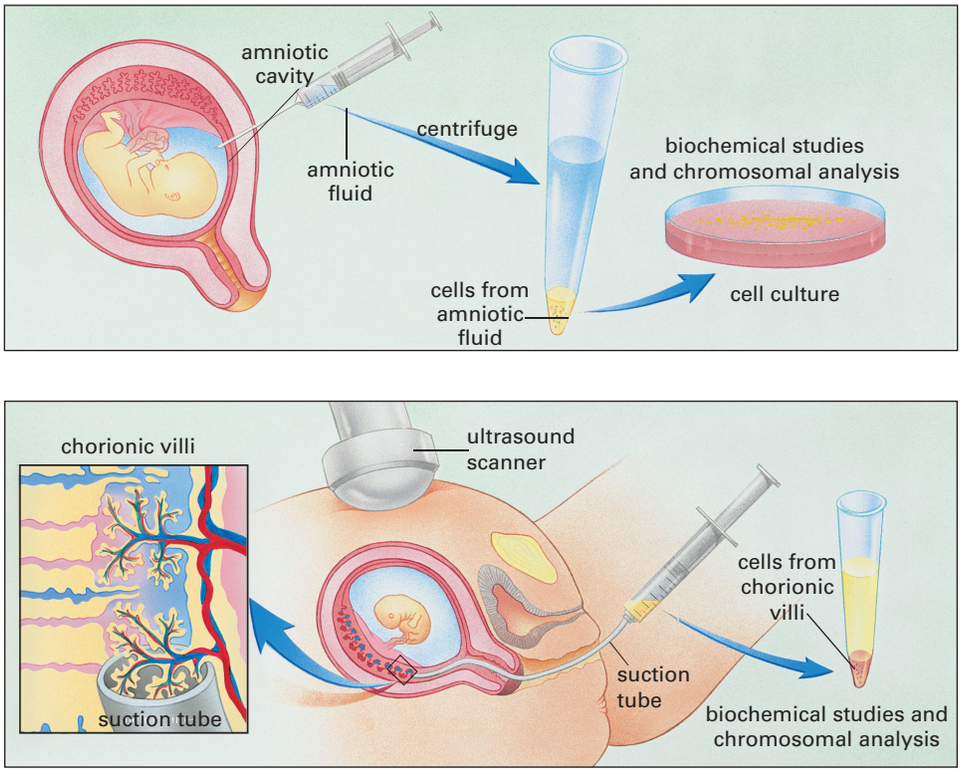


FIGURE 3.10
Amniocentesis and Chorionic Villi Sampling

The blood test is the first level of screening for possible fetal variations and may be administered in the first trimester. If it is, there is a one-in-10 to one-in-20 chance of a false-positive reading, depending on maternal age (Health Canada, 2002). This test is administered to women 14 to 20 weeks into pregnancy only when they are at risk of bearing a child with defects in the formation of the brain and spinal cord.

Infertility and Reproductive Technology

The first national assessment of infertility in Canada was conducted in 1991 by the Royal Commission on New Reproductive Technologies (Baird, 1993). Approximately 8.5 percent of couples in Canada (nearly 300,000 couples) experience infertility, which is defined as the inability to conceive a child after 12 months of regular intercourse without contraception. The figure drops to 7 percent (approximately 250,000 couples) if infertility is defined as being a 24-month period with no pregnancy after regular intercourse without contraception. Thus, one in five couples, considered infertile under the 12-month definition, achieve a pregnancy within the next year (Baird, 1993). The Royal Commission on New Reproductive Technologies concluded that the use of a two-year time frame was more appropriate for assessing infertility but noted that many international studies use a one-year time frame.

The cause of infertility can rest with the woman or the man (Amin & others, 2006). Twenty-four percent of couples seen in fertility clinics at the beginning of the 1990s were "infertile because of a diagnosed problem in the male partner" (Baird, 1993, p. 402). The woman may not be ovulating, she may be producing abnormal ova, her fallopian tubes may be blocked, or she may have a disease that prevents implantation of the ova. The man may have a seminal problem, either too few sperm (a condition called oligospermia), or no sperm (a condition called azoospermia), the sperm may lack motility (the ability to move adequately), or the man may have a blocked passageway (Jesjat & Lo, 2006; Kumar & others, 2006). (See figure 3.11.) William Buckett, of McGill University, suggests that without treatment, women who ovulate infrequently might take up to a decade or more to become pregnant (Buckett, 2004). In the past, this time line was not a major issue in a marriage that could begin at age 18 or 20. But with women today

FIGURE 3.11
Fertility Problems, Possible Causes, and Treatments

MEN		
Problem	**Possible Causes**	**Treatment**
Low sperm count	Hormone imbalance, varicose vein in scrotum, possibly environmental pollutants Drugs (cocaine, marijuana, lead, arsenic, some steroids and antibiotics) Y chromosome gene deletions	Hormone therapy, surgery, avoiding excessive heat
Immobile sperm	Abnormal sperm shape Infection Malfunctioning prostate	None Antibiotics Hormones
Antibodies against sperm	Problem in immune system	Drugs
WOMEN		
Problem	**Possible Causes**	**Treatment**
Ovulation problems	Pituitary or ovarian tumour Underactive thyroid	Surgery Drugs
Antisperm secretions	Unknown	Acid or alkaline douche, estrogen therapy
Blocked fallopian tubes	Infection caused by IUD or abortion or by sexually transmitted disease	Surgical incision, cells removed from ovary and placed in uterus
Endometriosis (Tissue buildup in uterus)	Delayed parenthood until the thirties	Hormones, surgical incision

waiting longer to get married and start a family (possibly into their early thirties), this period of time would place them in the age range where fertility normally declines, thus not giving them enough time to successfully conceive. Other causes for fertility problems noted by Buckett include tubal disease (related to sexually transmitted diseases) and obesity-related infertility.

In some cases of infertility, surgery may correct the cause. The Royal Commission on New Reproductive Technologies examined three forms of infertility treatment: fertility drugs, assisted insemination (AI), and in-vitro fertilization (IVF). The most common form of fertility treatment in Canada is the use of fertility drugs. The Commission found that many of the drugs in use do not have research that clearly supports their effectiveness.

The oldest form of assisting a woman to become pregnant when she or her partner are subfertile, or her partner infertile, or when a woman wishes to have a baby without a male partner, is assisted insemination, or AI. In this procedure, the sperm of either the women's partner or that of a donor is placed in the vagina, near the cervix, or in the uterus. AI is the most common fertility procedure available in Canada. The Commission found AI to have "the potential to be a safe, inexpensive, and relatively low-tech" method to treat infertility. Yet, they raised concerns for the storage and handling of sperm, the definition of success, and the variations in procedural technique employed across the country.

The third form of infertility treatment studied by the Commission has received the most media coverage. The use of high-tech IVF procedures has the image of advanced science at work to correct infertility problems. The basic idea of IVF is that the egg and sperm are removed from the couple, and both egg and sperm (or one of them) are subjected to one of several procedures to enhance the likelihood of fertilization. The Canadian Fertility and Andrology Society (CFAS, 2002), in examining 19 of the 23

Canadian centres for in-vitro fertilization, found that in 2000 "the overall live birth rate was 20 percent per" attempts made. In 2001, the overall pregnancy rate climbed to 28 percent. The Royal Commission found that the definition of success varied widely across facilities and among doctors, institutions, and patients. The standard of practice with IVF procedures also was found to vary greatly across Canada. The Commission's recommendation that the federal government create a National Reproductive Technologies Commission to oversee fertility and reproductive technology has not yet been acted upon.

One consequence of fertility treatments is an increase in multiple births. According to the Multiple Births Association of Canada (2001), 15 to 17 percent of multiple births result from infertility treatments. Specifically, they estimate that 90 percent of quadruplets and 99 percent of quintuplets are the outcome of infertility treatments. Though parents may be thrilled at the prospect of having children, they also face serious risks. Nearly 50 percent of twins and more than 90 percent of triplets, quadruplets, and quintuplets are born prematurely and/or with low birth weight. Multiple-birth children are five times likelier to have birth disabilities.

Although multiples are likely to result from fertility treatments, two-thirds of pregnancies employing assisted reproduction technology are singletons (CFAS, 2002). Helmerhorst, Perquin, Donker, and Keirse (2004) reviewed studies examining the perinatal outcome after assisted conception and found that singletons were significantly more at risk for preterm birth, for a caesarean birth, admissions to neonatal intensive care units, and possibly low birth weight than were singletons conceived naturally. The same study, however, pointed out that twins who were conceived with assisted conception were more similar in outcome to naturally conceived twins, with some slight advantages, including a 40-percent lower perinatal mortality rate. This difference between singleton and twin assisted reproduction birth outcomes may be a result of the implantation procedures favouring the carrying to term of a multiple birth over the natural conception of twins.

Critical Thinking

Originally introduced in 2002, Bill C-13, The Assisted Human Reproduction Act, was passed by the House of Commons in 2003. Bill C-13 was referred to the House for amendment in 2005, then to a Standing Committee for discussion. The Act, which falls under the jurisdiction of Canada's Criminal Code, prohibits human cloning and the creation of an embryo for scientific purposes. The amendment, which was not passed in 2006, would have allowed for the creation of a DNA databank for those convicted of criminal activity. Identify the advantages, disadvantages and interesting possibilities related to Bill-C-13.

Adoption

Although surgery and fertility drugs can solve the infertility problem in some cases, another choice is to adopt a child. Adoption is the social and legal process by which a parent–child relationship is established between persons unrelated by birth. Researchers have found that adopted children and adolescents often show more psychological and school-related problems than nonadopted children (Brodzinsky & others, 1984; Brodzinsky, Lang, & Smith, 1995). Adopted adolescents are referred to psychological treatment two to five times as often as their nonadopted peers (Grotevant & McRoy, 1990). The increased number of adopted children in counselling may be because their adoptive parents belong to a higher socio-economic group and are more aware and willing to make use of mental health services (Warren, 1992; Haugaard, 1998).

In one recent large-scale study of 4,682 adopted adolescents and the same number of nonadopted adolescents, adoptees showed slightly lower levels of adjustment (Sharma, McGue, & Benson, 1996). However, adoptees actually showed higher levels of prosocial behaviour. Also, the later adoption occurred, the more problems the adoptees had. Infant adoptees had the fewest adjustment difficulties; those adopted after they were 10 years of age had the most. Other research has documented that early adoption often has better outcomes for the child than later adoption. At age six, children adopted from an orphanage in the first six months of their lives showed no lasting negative effects of their early experience. However, children from the orphanage who were adopted after they were six months of age had abnormally high levels of cortisol, indicating that their stress regulation had not developed adequately (Chisholm, 1998; Ambert, 2003).

York University professor Anne-Marie Ambert (2003) suggests that the position of the adopted person in our society is a socially constructed one and that it is most often not a positive position. She notes our society's orientation toward a "genetic consciousness," where genetic lineage is portrayed as critical for a positive sense of self and personal completeness, places the adopted person in an awkward position, and possibly elicits negative responses to their circumstances. This social construction is seen in the language used to describe both adoption and the relationship between adopting

SPOTLIGHT ON SOCIAL POLICY

Ethical Considerations of Stem Cell Research and Genetic Screening: An Overview

Canadian scientists, hematologist, Ernest A. McCulloch and biophysicist, James E. Till, discovered the first stem cell in the 1960s while experimenting with bone marrow in laboratory mice. Their discoveries led to bone marrow transplantation, which has been widely used to prolong the lives of leukemia patients and patients with other types of blood cancers (Smith, 2005). In doing so, they also opened the field of stem cell research, a field rich with potential for human health and at the same time wrought with ethical controversy. Let's start with a brief description of stem cell research and its implications, followed by a discussion of the role of genetic screening, and then examine Canada's position on these controversial issues, as well as the position taken by other countries.

James Till, MD, left, and Ernest McCulloch, MS, both from the University of Toronto, receive the 2005 Lasker Award for Basic Medical Research in New York City on Friday, Sept. 23, 2005, for their ground-breaking work in stem cell research.

Stem cells are cells that have the ability to renew themselves through cell division (mitosis). They can be taken from human tissue, dead or alive, adult or fetal (McLean, 2001). Human embryonic stem cells are fertilized eggs taken from an in-vitro laboratory. Called blastocysts, they are a 3–5 day old embryos. Through a complex process conducted in laboratories, blastocyst stem cells are cultured into what are called cell-lines. They can be transformed into cell types such as those found in human organs (e.g., the heart or pancreas). Scientists need access to many cell-lines in order to better understand how undifferentiated cells become differentiated, or how a cell with no particular properties (undifferentiated) takes on the properties (differentiated) such as the functional cell of an organ (National Institute of Health).

The critical part of the controversy is the ethical debate over when life begins. Is a cell the beginning of life or does life develop and thus become more valued over time? Those that argue in favour of stem cell research argue that the blastocyst is a ball of 30 cells, nothing more. Those who oppose it contend that the cell has all the potential of a human life and therefore must be safeguarded. If the cell is not the beginning of life, then, another profound and fundamental question is about creation and human nature itself: Are we an evolutionary species that reflects the process of natural selection and mutation, or, by genetic manipulation, will we be encouraging self-evolution? (Subbanna, 2006) If so, to what end?

Couples undergoing in-vitro fertilization often have embryos they no longer need. Should these be discarded or may they be used for research? Not only is the question of when cells have value inherently as the beginning of discrete human entity at stake, but more concretely, at stake, too, is the issue of informed consent. Ethical principles in all research require that participants provide informed consent. Participants must know exactly what the research entails. Obviously an embryo can not give informed consent, nor is it certain that adult donor consent is or can be fully informed as the conditions surrounding this relatively new research are not always precisely fixed (Subbanna, 2006; McLaren, 2001).

Genetic research is increasingly able to determine an individual's chances of developing one or more of a long list of common conditions such as asthma, heart conditions, arthritis, diabetes, and cancer through genetic screening. But this too raises numerous questions. If we, through genetic screening, learn we have the potential for particular diseases or conditions, what would we do with that information? Who would have access to it? Would insurance companies be able to request genetic information then on the basis of this information to decide to limit who can buy insurance? Would employment opportunities be affected? Further, there is the issue of how reliable and predictive genetic information from screening would be. Will health care providers be able to keep up with the vast amount of information to advise clients? (King, 2007). The interplay of genetic and environmental factors that influence the likelihood of developing a condition or its probable severity are only cursorily understood (King, 2007; McLean, 2001).

Bill C-13, Canada's Assisted Human Reproduction Act, is "an act respecting assisted human reproduction and related research" (Health Canada, October 2003). The Bill sets the restrictions that regulate the form and practice of activities to help people with fertility needs and to conduct research in the area of reproduction and reproductive technology. Bill C-13 prohibits cloning, the buying and selling of human sperm and eggs and places strict regulations on using in-vitro human embryos for research purposes. People who engage in the use of human embryos for experimental purposes will be tried in criminal court.

Regulations around stem cell research exist in other parts of the world as well. In the United States, in 2006,

after lengthy debate in the House of Representatives and the Senate, a bill to allow government funding of stem cell research was passed. However, President Bush categorized the stem cell research as a form of abortion, and vetoed the bill (Nature, 2006). Private labs, however, may operate lawfully and without government funding. Only a few days after Bush's veto, the United Kingdom and the European Union both announced funding for stem cell research.

Australia, China, India, Japan, Israel, Sweden, Singapore and the United States, as well as Canada and others have reported having cell lines; but they are very few. For example, the U.S. has 100, Sweden, 55, and Canada only two. China, without any regulations or guidelines on this matter, reports having cell lines but does not have a count (Nature, 2006; McLean, 2001). Though not yet safe for human use, bio-tech companies in Australia and Singapore, working collaboratively, report culturing four safe cell lines which they plan to make available worldwide (Nature, 2006). If Canada maintains its position that not only prohibits stem cell research, but criminalizes it, will some of our best geneticists find work in other countries where they can pursue their scientific interests lawfully?

As the controversy and debate capture worldwide media attention, public expectation and speculation escalates. Some people look forward to cures and treatments; others are horrified by the notion of growing human organs in a laboratory. However these organs could be used not only for transplants, but also, to test new medical therapies. Just as with the emerging field of neuro-psychoanalysis discussed in Chapter 2, considerable uncertainty exists. Even countries where stem cell research is publicly funded and lawful are proceeding cautiously because of ethical concerns.

parent and child. Further, many assume that adoptive parents will not feel as close to their adopted children as biological parents. Ambert reports that adoptive parents are usually equally attached to their adopted children and their biological children, if they have them. Yet, Ambert cites several examples where the adoptive parents were clearly confronted by society's refusal to accept their uncompromised attachment to their children.

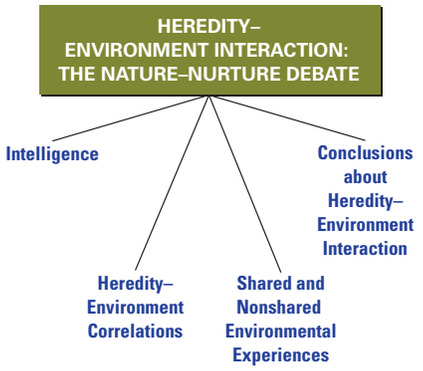
A question that virtually every adoptive parent wants answered is, "Should I tell my adopted child that he or she is adopted? If so, when?" Most psychologists believe that adopted children should be told that they are adopted because they will eventually find out anyway. Many children begin to ask where they came from when they are approximately four to six years of age. This is a natural time to begin to respond in simple ways to children about their adopted status. Clinical psychologists report that one problem that sometimes surfaces is the desire of adoptive parents to make life perfect for the adoptive child and to present a perfect image of themselves to the child. The result, too often, is that adopted children feel that they cannot release any angry feelings or discuss problems openly in this climate of perfection (Warshak, 1997).

To this point, we have discussed a number of ideas about reproduction challenges and choices. A review of these ideas is presented in summary table 3.3. In our discussion of adoption, we indicated that children who are adopted later in their development often show more difficulties than those who are adopted very early in their lives. This finding suggests that the environment plays an important role in children's development.

Summary Table 3.3 Reproduction Challenges and Choices

Concept	Characteristics/Description
Prenatal Diagnostic Tests	• Amniocentesis, ultrasonography, chorionic villi sampling, and the maternal blood test are used to determine the presence of defects once pregnancy has begun.
	• Genetic counselling has increased in popularity because couples desire information about their risk of having a child with defective characteristics.
Infertility	• Some infertility problems can be corrected through surgery or fertility drugs.
	• Methods include in vitro fertilization and other more recently developed techniques.
Adoption	• Adopted children and adolescents have more problems than their nonadopted counterparts. • When adoption occurs very early in development, the outcomes for the child are improved.

HEREDITY–ENVIRONMENT INTERACTION: THE NATURE–NURTURE DEBATE



Heredity and environment interact to produce development (McGuire, 2001). To explore this interaction, we will focus on an important area of development—intelligence—and then explore many other aspects of heredity–environment interaction.

Intelligence

Occasionally, scholarly research can be quite biased sparking sometimes contentious and hostile controversy. One such example is research on intelligence. Some scholars have tried to prove the supremacy of one gender or race over another. Needless to say, these positions have been refuted. Two such contentious publications were those of Arthur Jenson in 1969 and of J. Phillippe Rushton in 1985.

In 1969, when Arthur Jenson presented his thesis that intelligence is primarily inherited, he argued that environment and culture play a minimal role in intelligence. His research was based on comparisons of identical twins who could be expected to have identical intelligence and fraternal twins who are no more genetically similar than ordinary siblings. He found a higher correlation (0.82) among identical twins than among fraternal twins (0.50). To test his theory further, he then compared identical twins who were raised together to those who were raised apart. Those raised together had a slightly higher correlation (.079) than those raised apart (0.78). He argued that if environmental influences are more important than genetic influences, then siblings who were reared apart and experienced different environments should have IQs much further apart.

Later, in 1985 and 1990, J. Phillippe Rushton of the University of Western Ontario, flamed the fires of debate when he announced that a thorough review of all sources revealed that genetic differences existed between racial groups for the heritable nature of such factors as intelligence, family size, spacing of births, incidence of DZ twinning, parental care, altruism, law-abiding behaviour, and sex drive. He stated that people of the Mongoloid race (Asians and Amerindians) were superior on all these traits to Caucasians (whites of European ancestry), who, in turn, were superior to blacks of African origin. These alleged genetic differences were also found between people of the upper socio-economic class versus those of the lower socio-economic class. Much of this research was supported by Ruston and Ankney's (1996) assumption that their examination of MRIs showed different brain sizes between three racialized groups. Whenever the anatomical differences in the brain have been studied, researchers refute the possibility that brain-size is reliably connected to intelligence, and argue that other factors (e.g. synaptic density) are more important predictors of intelligence (Purves and others, 2001). Many scholars question both Rushton's motives and the validity of his research. Some objections are outlined below.

James Flynn has been one of several researchers who have doggedly critiqued Phillipe Rushton's work. An Emeritus Professor from the University of Otago, New Zealand, James Flynn also studies the political and moral grounds for "justifying human ideals."

Michael Peters (1995), of the University of Guelph, challenged Rushton's findings concerning brain size and intelligence. According to Peters, Rushton's findings indicate that there is more variation within each "racial" grouping than between them. Rushton proposed that men's larger brain size explained why they achieved higher intelligence test scores than women. Peters suggests that there is more to the brain and its functioning than simply its size, however measured.

James Flynn (1999), of New Zealand, finds these studies both racist and offensive. He states that intelligence test score differences between "races," cited by both Jensen and Rushton, can be accounted for by environmental differences and are not genetic qualities. Colom, Juan-Espinosa, and Garcia (2001) support Flynn's conclusion by finding generation gaps in intelligence scores which match the observed contemporary gaps between "races." Colom et al. believe that this finding rules out evidence suggesting a genetic cause and that we ought to focus our attention instead on environmental conditions that influence intelligence test scores.

Assigning aptitudes and abilities to one gender or the other is also controversial. You may have heard or read that some researchers have suggested that male brains are better at math and female brains are better in languages. No definitive research supports these findings; however, on January 14, 2006, Harvard University President, L.H. Summers proposed that innate genetic differences between men and women may be one

explanation for why fewer women succeed in science careers. Like many, The National Organization for Women (NOW), finding these remarks sexist and offensive, demanded his resignation. Within a month, Summers resigned (February, 2006), but his remarks fueled the debate once again (Eltis, 2007).

Most experts today agree that the environment plays an important role in intelligence (Brody, 2000; Ceci & others, 1997; Di Lalla, 2000; Patrick, 2000; Sternberg, 2001; Sternberg & Grigorenko, 2001). This means that improving children's environments can raise their intelligence. Consider the experiences of 20 children in France who had been abandoned in infancy by their parents of low socio-economic status and subsequently adopted by parents of upper-middle socio-economic status. These children all had biological siblings who remained with their biological mothers and were reared in impoverished circumstances. No factors that might have made the children who were adopted more genetically promising could be found. When tested in the elementary school years, the adopted children's IQs averaged 14 points higher than the IQs of their biological siblings (Schiff & others, 1982).

Heredity–Environment Correlations

Heredity–environment correlations involve the interpretation of the complexities of heredity-environment interactions. An individual's genes may influence the types of environments to which they are exposed. In a sense, individuals inherit environments that may be related or linked to genetic tendencies (Plomin & others, 2003). Behaviour geneticist Sandra Scarr (1993) described three ways that heredity and environment are correlated: passively, evocatively, and actively.

According to Sandra Scarr, what are three ways that parents can contribute to genotype–environment correlations?

Passive genotype–environment correlations *occur when biological parents, who are genetically related to the child, provide a rearing environment for the child.* For example, the parents might have a genetic predisposition to be intelligent and read skilfully. Because they read well and enjoy reading, they provide their children with books to read. The likely outcome is that their children, given their own inherited predispositions, will become skilled readers.

Evocative genotype–environment correlations *occur because a child's genotype elicits certain types of physical and social environments.* For example, active, smiling children receive more social stimulation than passive, quiet children do. Cooperative, attentive adolescents evoke more pleasant and instructional responses from the adults around them than uncooperative, distractible adolescents do. Athletically inclined youth tend to elicit encouragement to engage in school sports. As a consequence, these adolescents tend to be the ones who try out for sport teams and go on to participate in athletically oriented environments.

Active (niche-picking) genotype–environment correlations *occur when children and adolescents seek out environments they find compatible and stimulating.* Niche-picking refers to finding a niche or setting that is suited to one's abilities. Adolescents select from their surrounding environment some aspect that they respond to, learn about, or ignore. Their active selections of environments are related to their particular genotype. For example, attractive adolescents tend to seek out attractive peers. Adolescents who are musically inclined are likely to select musical environments in which they can successfully employ their skills.

Scarr believes that the relative importance of the three genotype–environment correlations changes as children develop from infancy through adolescence. In infancy, much of the environment that children experience is provided by adults. Thus, passive genotype–environment correlations are more common in the lives of infants and young children than they are for older children and adolescents who can extend their experiences beyond the family's influence and create their environments to a greater degree. The neuro structures in children are molded and transformed by environment; however, in adolescence, we stop changing our minds to fit the world and instead try to change the world to fit our minds (Wexler, 2006).

passive genotype–environment correlations
Correlations that exist when the natural parents, who are genetically related to the child, provide a rearing environment for the child.

evocative genotype–environment correlations
Correlations that exist when the child's genotype elicits certain types of physical and social environments.

active (niche-picking) genotype–environment correlations
Correlations that exist when children seek out environments they find compatible and stimulating.

Shared and Nonshared Environmental Experiences

shared environmental experiences
Children's common environmental experiences that are shared with their siblings, such as their parents' personalities and intellectual orientation, the family's social class, and the neighbourhood in which they live.

nonshared environmental experiences
The child's own unique experiences, both within the family and outside the family, that are not shared by another sibling. Thus, experiences occurring within the family can be part of the "nonshared environment."

Shared environmental experiences *are children's common experiences, such as their parents' personalities and intellectual orientation, the family's social class, and the neighbourhood in which they live.* By contrast, **nonshared environmental experiences** *are a child's unique experiences, both within the family and outside the family, that are not shared with another sibling.* Thus, experiences occurring within the family can also be part of the "nonshared environment."

Behaviour geneticist Robert Plomin (1993) has found that common rearing, or shared environment, accounts for little of the variation in children's personality or interests. In other words, even though two children live under the same roof with the same parents, their personalities often are very different. Heredity influeces the nonshared environments of siblings through the heredity-envioronment correlations described earlier (Plomin & others, 2003). For example, a child who has inherited a genetic tendency to be athletic is likely to spend more time in environments related to sports, while the child who has inherited a tendency to be musically inclined may spend more time in environments related to music.

The Epigenetic View

epigenetic view
The view that development is the result of the ongoing, bidirectional interchange between heredity and environment.

Does the concept of heredity-environment correlation downplay the importance of environment in our development? The concept emphasizes how heredity directs the kind of environmental experiences individuals have. However, earlier in the chapter we discussed how genes are collaborative, not determining an individual's traits in an independent manner, but rather in an interactive manner with the environment. In line with the concept of a collaborative gene, Gilbert Gottlieb (1998, 2003, 2004; Gottlieb, Wahlsten, & Lickliter, 2006) emphasizes the **epigenetic view**, *which states that development is the result of an ongoing, bidirectional interchange between heredity and the environment.*

Let's look at an example that reflects the epigenetic view. A baby inherits genes from both parents at conception. During prenatal development, toxins, nutrition, and stress can influence some genes to stop functioning while others become stronger or weaker. During infancy, environmental experiences such as toxins, nutrition, stress, learning, and encouragement continue to modify genetic activity and the activity of the nervous system that directly underlies behavior (Gottlieb, 2005). Heredity and environment operate together—or collaborate—to produce a person's intelligence, temperament, height, weight, ability to pitch a baseball, ability to read, and so on (Gottlieb, Wahlsten, & Lickliter, 1998, 2006; Moore, 2001).

Conclusions about Heredity–Environment Interaction

Genes and Parenting

In sum, both genes and environment are necessary for a person even to exist. Because the environment's influence depends on genetically endowed characteristics, we say the two factors interact (Mader, 1999). Humans are driven to match their internal neurological structures to the external environment (Wexler, 2006).

The relative contributions of heredity and environment are not formulaic, one part genes, one part environment; nor does full genetic expression occur at any one time such as at conception or birth.

The emerging view is that many complex behaviours likely have some genetic loading that gives people a propensity for a particular developmental trajectory (Plomin & others, 2003; Walker, Petrill & Plomin, 2005). Environment is as complex as the mixture of genes we inherit (Bronfenbrenner & Morris, 2006; Parke & Buriel, 2006; Scheidt & Windley, 2006; Spencer, 2006). Environmental influences range from the things we lump together under "nurture" (such as parenting, family dynamics, schooling, and neighbourhood quality) to biological encounters (such as viruses, birth complications, and even biological events in cells) (Greenough, 1997, 1999).

If there were a cluster of genes somehow associated with individual violence (this is hypothetical because we do not know of any such combination), the environment in which the child with this gene cluster grows up would be another major contributing factor to the type of person the individual eventually becomes. The individual might experience a world of loving parents or neglect, a safe neighbourhood or one where

gunshots and crime are everyday occurrences, good educational opportunities or inadequate schooling. In which of these environments are the individual's genes likely to manufacture the biological underpinnings of criminality? Growing up with many of the "advantages" does not guarantee success any more than growing up with many disadvantages guarantees failure. People who grew up in privileged families might take opportunities for granted and fail to develop the motivation to succeed. By the same token, people who grow up in impoverished conditions may make the best of the opportunities available to them and learn to seek out advantages that can help them improve their lives.

The most recent nature–nurture controversy erupted when Judith Harris (1998) published *The Nurture Assumption*. In this provocative book, she argued that what parents do does not make a difference in their children and adolescents' behaviour. Yell at them. Hug them. Read to them. Ignore them. Harris says parental behaviour will not influence how children turn out. She argues that genes and peers play a far more important role than parents in children and adolescents' development.

Harris is right that genes and peers matter, although her descriptions of peer influences do not take into account the complexity of peer contexts and developmental trajectories (Hartup, 1999). In addition to not adequately considering peer complexities, many believe that Harris is wrong in her assessment that parents do not matter. Critics argue that to begin with parents play an important role in the child's early years by selecting peers, thus, indirectly influencing children's development (Baumrind, 1999). An abundance of parenting literature supported by many research studies document the importance of parents in children's development (Collins & others, 2000, 2001; Maccoby, 2000). We will discuss parents' important roles throughout this book.

Canadian psychologist Gordon Neufeld and physician Gabor Mate (2004) support the nurture argument. In their book *Hold On to Your Kids: Why Parents Matter*, they find that some parents distance themselves from their children during the early years, allowing the children to spend most of their time with other children. Neufeld and Mate say this results in a stronger attachment with peers than with parents for these children. The results are often a complete rejection of parental authority, influence, and connection during adolescence, a time when parental attachment might prevent or at least soften some of the problems teenagers can encounter. Thus, Neufeld and Mate believe a strong and nurturing attachment with their parents is critical for adolescent's positive experience of life. Perhaps it is in our nature to be nurtured.

To this point, we have discussed a number of ideas about heredity–environment interaction. To review these ideas see summary table 3.4.

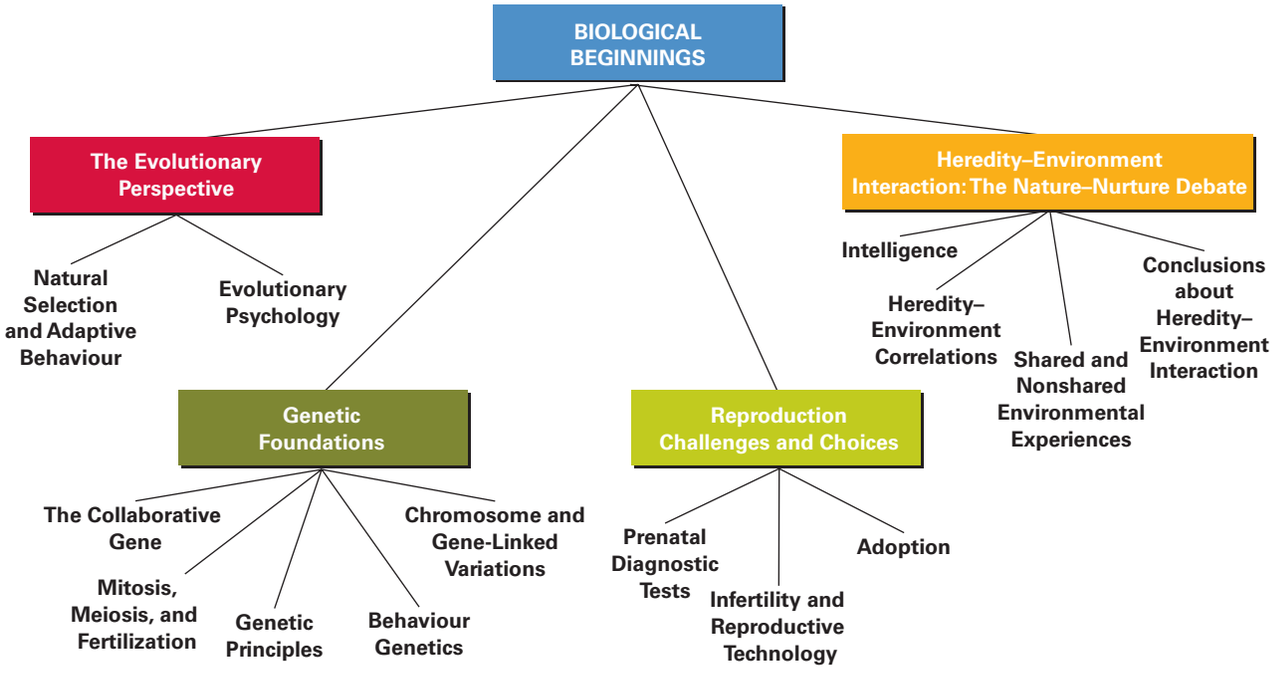
Critical Thinking

Harris as well as Neufeld and Mate represent two extremes in the argument about how important parents and peers are in shaping personality and life experience. From your own experiences, which do you believe is more correct? What features of your experience lead you to this opinion? What would have had to be different for you to hold the opposite view?

Summary Table 3.4 Heredity–Environment Interaction

Concept	Characteristics/Description
Intelligence	• Jensen argues that intelligence is mainly due to heredity. • Most experts today accept that the environment plays an important role in intelligence.
Heredity–Environment Correlations	• Sandra Scarr argues that the environments parents select for their children depend on the parents' genotypes. • Passive genotype–environment, evocative genotype–environment, and active (niche-picking) genotype–environment are three correlations. • Scarr believes the relative importance of the these three genotype–environment correlations changes as children develop.
Shared and Nonshared Environmental Experiences	• These refer to siblings' common experiences. • These refer to the child's unique experiences.
Complexity: Conclusions about Heredity–Environment Interaction	• Many complex behaviours have some genetic loading that gives people a propensity for a particular developmental trajectory. • Actual development also requires an environment, and that environment is complex. • The interaction of heredity and environment is extensive.

CHAPTER REVIEW



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